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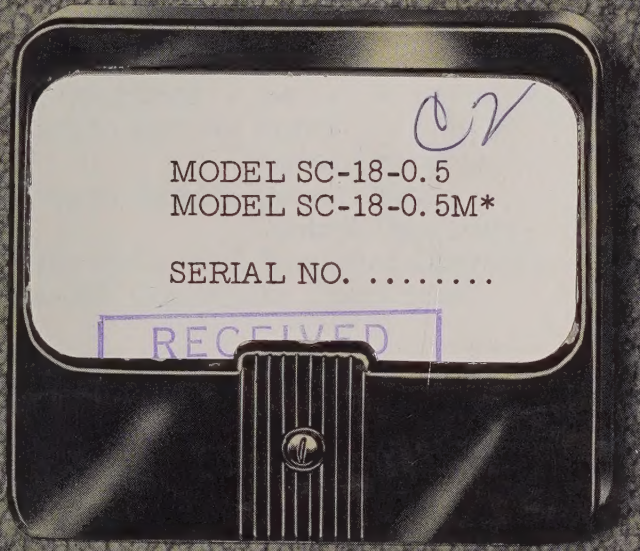
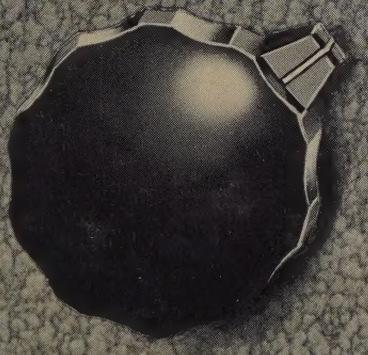
VRPS*



* VOLTAGE REGULATED POWER SUPPLIES



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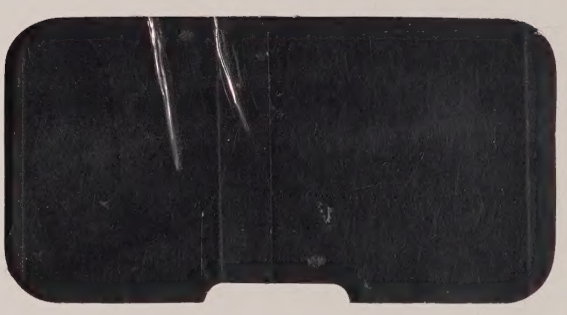

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SECTION A

ELECTRICAL AND PHYSICAL SPECIFICATIONS

.....AC INPUT:

105-125 volts, 50-65 CPS single phase, 0.5 ampere (maximum), 46 watts (maximum).

.....DC OUTPUT VOLTAGE:

0-18 volts continuously variable.

.....DC OUTPUT CURRENT:

0-0.5 ampere continuous duty.

.....REGULATION:

Load Regulation: 0.1% or 0.003 volt, whichever is greater, for load variation from 0 to 0.5 ampere.

Line Regulation: Less than 0.1% for line fluctuation from 105-125 volts.

.....RIPPLE VOLTAGE:

Less than 1 millivolt RMS under all conditions.

.....STABILITY:

Approximately 3/4 of an hour is required for this power supply to reach equilibrium from a "cold start". The drift during the warm-up time is less than 1/2%.

The output voltage variation is less than 0.1% or 0.006 volt, whichever is greater, for a period of 8 hours after reaching equilibrium.

.....TEMPERATURE COEFFICIENT:

Output voltage changes less than 0.05% per °C.

.....OUTPUT IMPEDANCE:

Less than 0.04 ohm from DC to 1 KC.

Less than 0.4 ohm from 1 KC to 100 KC.

.....RECOVERY TIME:

50 microseconds.

.....AMBIENT OPERATING TEMPERATURE:

-20°C to 50°C.

.....STORAGE TEMPERATURE:

-40°C to +95°C.

.....INPUT AND OUTPUT TERMINATIONS:

DC terminals are clearly marked on the front panel. All terminals are isolated from the chassis. Either positive or negative terminal of the DC output may be grounded. A terminal is provided for connecting to the chassis. The DC terminals are also brought out to a barrier terminal board at the rear of the unit.

.....REMOTE OUTPUT VOLTAGE CONTROL: (OHMS/VOLT)

Two terminals on the rear terminal board are provided for remotely controlling the output voltage. FOR EACH 1,000 OHMS CHANGE IN REMOTE CONTROL RESISTANCE THE OUTPUT VOLTAGE CHANGES ONE VOLT.

.....REMOTE ERROR SIGNAL SENSING:

Two terminals on the rear terminal board are provided for remotely sensing the error signal directly at the load. This connection compensates for voltage drop in the wires connecting the power supply to the load.

.....PROTECTIVE FEATURES:

Current Limit Adjust - can be set from 0 to 120% of full load. Current is limited to pre-set value for any load including short circuit.

Over-Temperature Control - A pre-set temperature sensitive device will automatically turn off the equipment if the temperature of the pass transistors becomes excessive. To turn the power supply on again, once an over-temperature condition has occurred, remove the external load from the power supply and wait approximately 3 to 5 minutes for the unit to cool. After this interval turn the power switch OFF and then ON again. If the power goes off the unit has not cooled to a safe operating temperature.

Fuse Protection - Input fuse on front panel.

.....CONTROLS:

Power on-off switch; one turn voltage control on front panel.

.....*METERS:

Voltmeter: 0-20 volts, 2-1/2".

Ammeter: 0-0.5 ampere, 2-1/2".

.....DIMENSIONS:

Height 4-1/4", width 8-5/32", depth 13-5/8". This unit is designed for bench use and is enclosed in its own cabinet. Rack panel adapters are available for mounting either one or two of these units in a standard panel 19" wide, 5-1/4" high.

.....COLOR:

Kepco Standard Dark Gray Hammertone.

SECTION B.

THEORY OF OPERATION

The object of the following discussion is to obtain a brief qualitative view of some of the fundamental functional relationships among the elements of this power supply. A system of nomenclature has been introduced into this discussion solely to facilitate reference to the schematic circuitry. This nomenclature appears directly on the schematic diagrams in the REFERENCE INDEX. It should be recognized that terminology adopted for this purpose is only an internal standardization of the manufacturer but, as much as possible, the attempt has been made to conform to accepted engineering usage.

This power supply is of a servo or closed loop design in which the pass elements are in series with the load. The block diagram below demonstrates this.

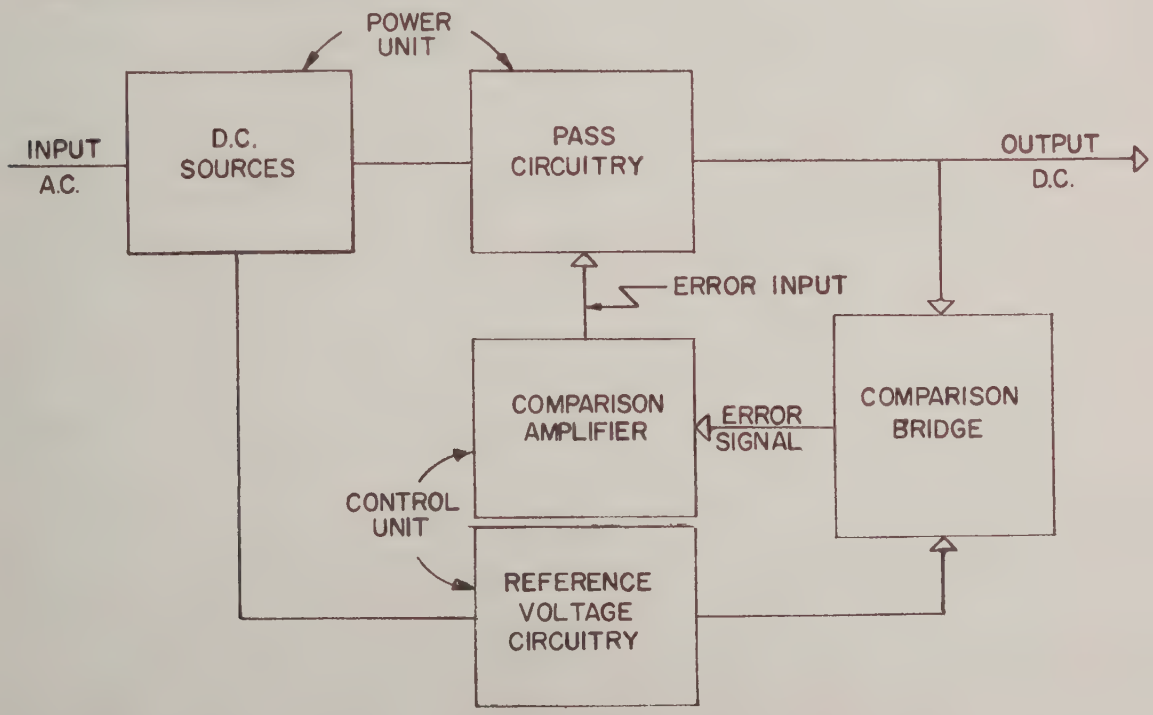


DIAGRAM B-1

The voltage drops in the closed loop are automatically adjusted according to the comparison of a sample output voltage with the reference voltage in the CONTROL UNIT*. Any imbalance originating in this comparison is amplified and functions as a feedback or ERROR INPUT* to control the voltage drop across the pass transistors. The ERROR INPUT* to the PASS CIRCUITRY* is negatively or degeneratively phased so that the consequent voltage drop across the pass transistors is such as to oppose output voltage change.

ALL "ASTERISKED" TERMS IN THE FOLLOWING OUTLINE REFER TO DESIGNATIONS ON THE SCHEMATICS IN THE REFERENCE INDEX.

..... I. POWER UNIT* (Schematic Title)

consisting of:

A. INPUT CONTROL CIRCUITRY* - Controls power input from the line to the DC SOURCES* - transformers.

B. DC SOURCES* - Provide main and auxiliary power for all DC circuitry.

C. PASS CIRCUITRY* - In the MAIN DC* path to the output. All current drawn by the load goes through the pass elements, hence the name.

..... II. CONTROL UNIT* (Schematic Title)

consisting of:

A. REFERENCE VOLTAGE CIRCUITRY* - Maintains a stable voltage standard for the comparison circuitry.

B. THE COMPARISON AMPLIFIER* - Functions as an "error sensing" and cascade amplification circuit.

.....III. COMPARISON BRIDGE*

consisting of elements of both the POWER UNIT* and CONTROL UNIT* in a circuit configuration which effects a comparison between a sample of output voltage and a stable reference voltage.

- - - - - - - - - - - - -

NOTE: The following discussion describes the elements of the foregoing outline in greater detail. As before, terms followed by an asterisk refer to designations on the schematic diagrams. Some of this discussion is of a general nature and may not apply in every detail to this specific model. Variations in the basic outline occur primarily in connection with the PASS CIRCUITRY* or the REFERENCE VOLTAGE CIRCUITRY* and reflect design considerations relevant to the particular output requirements of the model. It should not be assumed that a set of schematics is incomplete because it does not include all of the reference nomenclature used in this discussion.

.....I. POWER UNIT*

A. INPUT CONTROL CIRCUIT*: (a DC circuit)

(1) With the input switch closed, a forward bias on one semiconductor diode in the ENERGIZING CIRCUIT* will draw a charging current for the capacitor which energizes the INPUT RELAY* coil closing the input to the DC SOURCES* transformers. As soon as the relay is closed, the DC

in the input control circuit circulates through the thermal relay and input relay coil bypassing the charged capacitor and holding the relay closed.

(2) If the pass element containing the thermostat control becomes overheated, the thermal switch opens the DC path to the INPUT RELAY* de-energizing the relay coil and cutting off the input to the DC SOURCES* transformers.

NOTE: When the input to the DC SOURCES* has been opened by the thermal switch, it is necessary to throw the input toggle switch off and then on again to turn on the power supply. This is due to the fact that the ENERGIZING CIRCUIT* presents practically an open circuit to DC and cannot hold the relay closed after its time constant decay. This feature prevents damage to the pass elements in case the pass element containing the thermostat control dissipates heat faster than the other pass elements. Otherwise, an automatic on-off input control would lead to overheating and damage.

(3) When the input relay is opened by the action of the thermal switch or by pulling the line cord, the DISCHARGE RESISTOR* effectively shorts the MAIN FILTER CAPACITOR* preventing over-voltage surges.

B. DC SOURCES*:

(1) RETURN SUPPLY* (full wave rectified and filtered) - Provides a return path for leakage current (I_{CO}) from the pass transistors. It is also a bleed path which provides a minimum operating current for the emitters of the pass transistors enabling them to continue to remain operative or "sensitive" to the ERROR INPUT* when the load current becomes zero or vanishingly small.

(2) MAIN SUPPLY* (full wave rectified and filtered) - Provides MAIN DC* for the output, subject to the regulatory action of the PASS CIRCUITRY*. The MAIN DC* path includes the pass elements and the load in series.

(3) I_{CO} SUPPLY* (full wave rectified) - Provides a supply of current to prevent spurious biasing of the pass transistors by collector leakage current (I_{CO}). I_{CO} generated as a function of temperature and flowing oppositely to the emitter base current tends to alter the ERROR INPUT* unless this compensating supply provides bias stabilization.

(4) COLLECTOR SUPPLIES* (negative half-cycle rectification) - provide proper collector bias for the PRE-DRIVERS*.

C. PASS CIRCUITRY*:

The power transistors which function as pass elements may be regarded as electronic variable resistors (or variable conductors) controlled or "varied" by an amplified ERROR INPUT*. The amount of current "passed" by these transistors is a function of the magnitude of the forward conducting emitter-base bias. Since the ERROR INPUT* is applied to the base terminal, a negative input will aid the forward conducting bias of a PNP transistor while a positive input will reduce the forward conducting bias. Responding to the polarity and magnitude of the ERROR INPUT*, the pass transistors regulate the current and voltage distribution in the MAIN DC* loop and effect a constant output voltage.

There are two main classifications of pass transistors in this circuitry according to the way in which they are driven:

(1) DRIVEN PASS* - "driven" by the ERROR INPUT from the CONTROL UNIT*. A DRIVER* and a PRE-DRIVER* may be connected in cascade with the DRIVEN PASS*. These amplification stages increase the response and sensitivity of the system to output voltage changes. The DRIVEN PASS* may be a single series pass transistor or a series pass group of transistors connected in parallel.

(2) SLAVE PASS* - found in transistorized units requiring more than one series pass group in the MAIN DC* path. These pass transistors "slavishly" follow the response of the DRIVEN PASS* to the ERROR INPUT*. The SLAVE PASSES* are driven through a SLAVE VOLTAGE DIVIDER* which effects an approximately equal voltage division among the series pass groups, each of which may be a single series pass transistor or a series pass group of transistors connected in parallel. The SLAVE PASSES* may or may not have preliminary amplification stages in cascade.

- - - - - - - - - - - -

When series pass groups contain transistors connected in parallel, an EQUALIZING RESISTOR* is associated with each transistor. These EQUALIZING RESISTORS* tied to each emitter provide self-biasing compensation for intrinsic operating characteristic differences, equalizing current distribution among the transistors.

The expression "drop voltage" is sometimes used to describe the amount of voltage drop required of the pass elements to bring the COMPARISON BRIDGE into balance. This, of course, is the difference

between the input and the desired output. True balance or stability is inherently impossible in a servo system, but the imbalance may be reduced to as small a magnitude as desired in a dynamically corrective system.

..... II. CONTROL UNIT*

A. REFERENCE VOLTAGE CIRCUITRY:*

The function of the REFERENCE VOLTAGE CIRCUITRY* is to maintain a precise, stable voltage for the COMPARISON BRIDGE. This is achieved according to the type of CONTROL UNIT* with either of two basic design approaches:

(1) A CASCADE ZENER REFERENCE*, consisting of Zener diodes of successively decreasing values in cascaded stages each of which produce an increasingly regulated reference voltage. In practice, usually only two stages are used so that in effect the first Zener diode is a regulator for a voltage reference diode.

(2) Balanced amplifier regulation - Any disparity between the bases of the transistors in the set of 1st BALANCED AMPLIFIERS* is coupled to the set of 2nd BALANCED AMPLIFIERS*. The 2nd BALANCED AMPLIFIERS* couple this amplified "error signal" to a REFERENCE DRIVER* and a REFERENCE PASS* which regulate the current through a REFERENCE DIODE* in a manner analogous to the action of the PASS CIRCUITRY* in the POWER UNIT*.

B. COMPARISON AMPLIFIER CIRCUITRY*:

(1) The COMPARISON AMPLIFIER* consists of a series of cascaded transistor amplifiers which boost the "error input" to a sufficient level to drive the PASS CIRCUITRY* in the POWER UNIT*.

(2) The COMPARISON AMPLIFIER* is connected across the COMPARISON BRIDGE from the junction of the VOLTAGE CONTROL* and the REFERENCE RESISTANCE* to the junction of the Zener reference diode and the negative output terminal. (See Diagram B-2.) This situation is somewhat similar to that of the null galvanometer across a Wheatstone bridge. The imbalance in the COMPARISON BRIDGE is detected and amplified by the COMPARISON AMPLIFIER CIRCUITRY* beginning a chain of circuit responses which produce an ERROR INPUT* signal of proper phase and magnitude to effect corrective action by the pass circuitry.

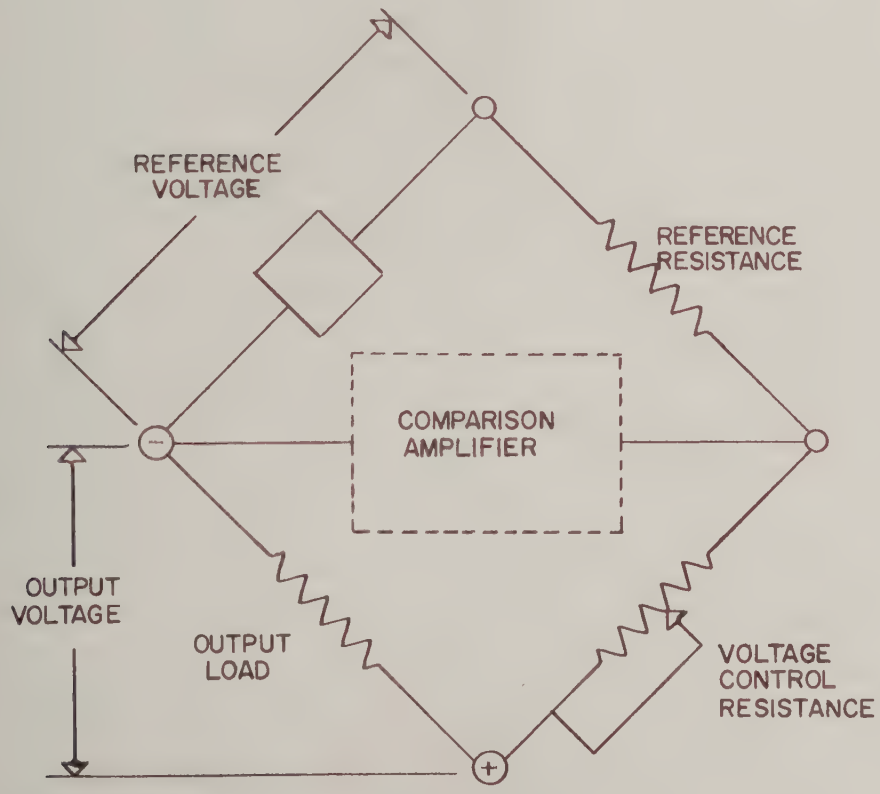


DIAGRAM B-2

.....III. COMPARISON BRIDGE:

(1) This bridge circuit implements the comparison between the OUTPUT VOLTAGE and the REFERENCE VOLTAGE the product of which drives the COMPARISON AMPLIFIER CIRCUITRY*.

(2) The COMPARISON BRIDGE is represented schematically in Diagram B-2.

(3) Balance occurs in the COMPARISON BRIDGE when the following ratios are equal:

$$\frac{\text{Output Voltage}}{\text{Voltage Control Resistance}} = \frac{\text{Reference Voltage}}{\text{Reference Resistance}}$$

(4) When an imbalance is caused in the COMPARISON BRIDGE by a decreasing output voltage drop across the load, it gives rise to a negative bias at the base of the COMPARISON FOLLOWER* in the COMPARISON AMPLIFIER CIRCUITRY*. This signal, amplified, acting as the ERROR INPUT* negatively biases the base of the DRIVEN PASS* aiding its forward conducting bias and increasing the output voltage.

(5) A bridge imbalance caused by an increasing output voltage produces, of course, a chain of oppositely biased circuit responses which reduce the voltage across the load.

SECTION C

OPERATING INSTRUCTIONS AND PROCEDURES

(Terms followed by an asterisk refer to designations on the schematic diagrams.)

....STANDARD OPERATION:

This regulated power supply is shipped without any internal packing material and may be put into operation immediately:

(1) Connect the input power.

(2) Adjust the VOLTAGE CONTROL* to the desired output.

.....CONVERSION OPERATION:

For increased versatility, most models may be adapted by simple external connections to operate with REMOTE ERROR SIGNAL*, REMOTE VOLTAGE CONTROL*, and CONSTANT CURRENT output. These procedures are described in the following paragraphs. DIAGRAMS FOR THESE PROCEDURES ARE TO BE FOUND ON THE PAGES IMMEDIATELY FOLLOWING THIS SECTION. These diagrams illustrate connections made with the terminal board. Schematic diagrams should be consulted to determine which terminals are available for a given model.

.....CONVERTING TO REMOTE ERROR SIGNAL OPERATION:

(See Diagram I.)

When the load is remotely located with respect to the power supply, or when load current requirements are high, the resistance of the output leads may appreciably deteriorate output regulation. In order to com-

pensate for undesirable voltage drops across these leads and obtain best regulation, the following connections should be made:

(1) WITH THE INPUT POWER DISCONNECTED remove the jumpers between the output terminals and the REMOTE ERROR SIGNAL* terminals.

(2) Using twisted pair wire, connect the positive and negative REMOTE ERROR SIGNAL* terminals to the load.

(3) Using twisted pair wire, connect the positive and negative output terminals to the load.

.....CONVERTING TO REMOTE OUTPUT VOLTAGE CONTROL:

(See Diagram II.)

(Not applicable to units whose design incorporates variable auto-transformers ganged to the VOLTAGE CONTROL* potentiometer.)

If it is desired to control the output voltage from a remote location, the following modifications must be made:

(1) Remove the jumpers from the positive and negative REMOTE OUTPUT VOLTAGE CONTROL* terminals. Using shielded twisted pair wire, bring leads from these terminals to the desired control location.

(2) Connect the shielded leads from the REMOTE OUTPUT VOLTAGE CONTROL* terminals to a resistance (fixed or variable) numerically equal to the desired output voltage multiplied by the ohms/volt ratio of the VOLTAGE CONTROL. **The ohms/volt ratio for this unit is specified in SECTION A. The maximum and

minimum ohmic value of a variable remote voltage control resistor is similarly determined as the product of the ohms/volt ratio and the maximum and minimum desired output voltages respectively.

**This unit is designed to operate in such a way that an equality is maintained between the following ratios: (See "RP Control" on Page E-3.)

$$\frac{\text{Output Volt.}}{\text{Volt. Ctrl. Res.}} = \frac{\text{Reference Volt.}}{\text{Reference Res.}}$$

Consequently, any resistor used for remote output control must maintain this ratio.

.....CONVERTING TO CURRENT REGULATED OPERATION:

(See Diagram III.)

(Not applicable to units with variable auto-transformer control.)

This power supply can be operated in such a manner that a constant current rather than constant voltage will be maintained in the external load. Applications for this type of modification include supplies for magnet coils, solenoids, and filament loads. Diagram III indicates the external electrical modifications required for converting to a constant current mode of operation. The essential changes are:

(1) Remove the minus remote output voltage control jumper.

(2) Connect a current "sensing" resistor R in series with the external load R_L. THE CURRENT "SENSING" RESISTOR VALUE IS SELECTED SO THAT THERE IS A ONE VOLT DROP ACROSS IT FOR MAXIMUM DESIRED OUTPUT CURRENT:

$$R_{\substack{\text{Current Sensing} \\ \text{Resistor}}} = 1/\text{Max. current desired}$$

(3) Connect a 2,000 MF capacitor across R_L.

(4) Connect a variable control resistor for setting the constant current value (see Diagram III.). The resistance of this control should be equal to the ohms/volt ratio for this unit specified in Section A.

NOTE: Constant current will be maintained throughout the load resistance range 0 to R_L (Max.). R_L (Max.) is determined by the ratio of the maximum rated output voltage to the desired constant current. For larger load resistance values the current through the current sensing resistor would not be sufficient to produce a one volt drop.

Greatest sensitivity and, consequently, best current regulation is possible when the largest value of current sensing resistor is used. Therefore, it is recommended that the current sensing resistor value be selected according to the maximum output current desired for a given operation.

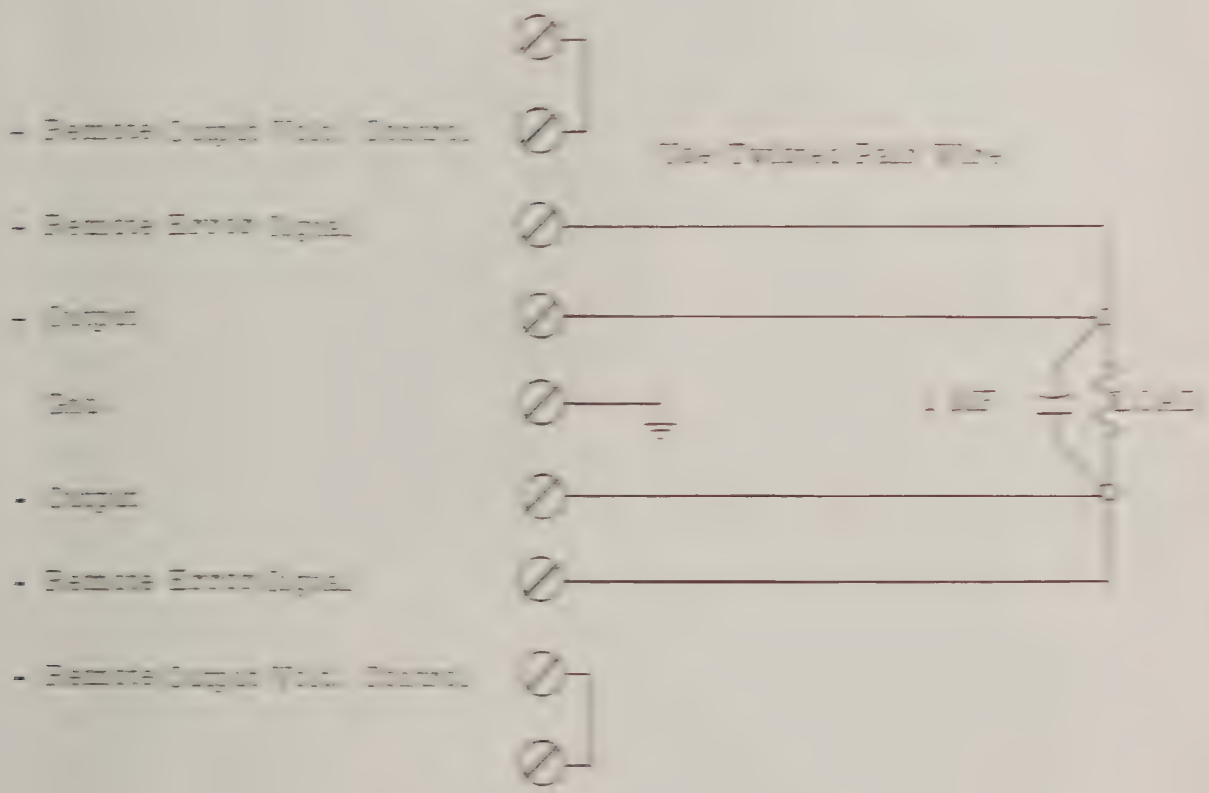


DIAGRAM 1

CONVERTING TO REMOTE OUTPUT VOLTAGE CONTROL OPERATION

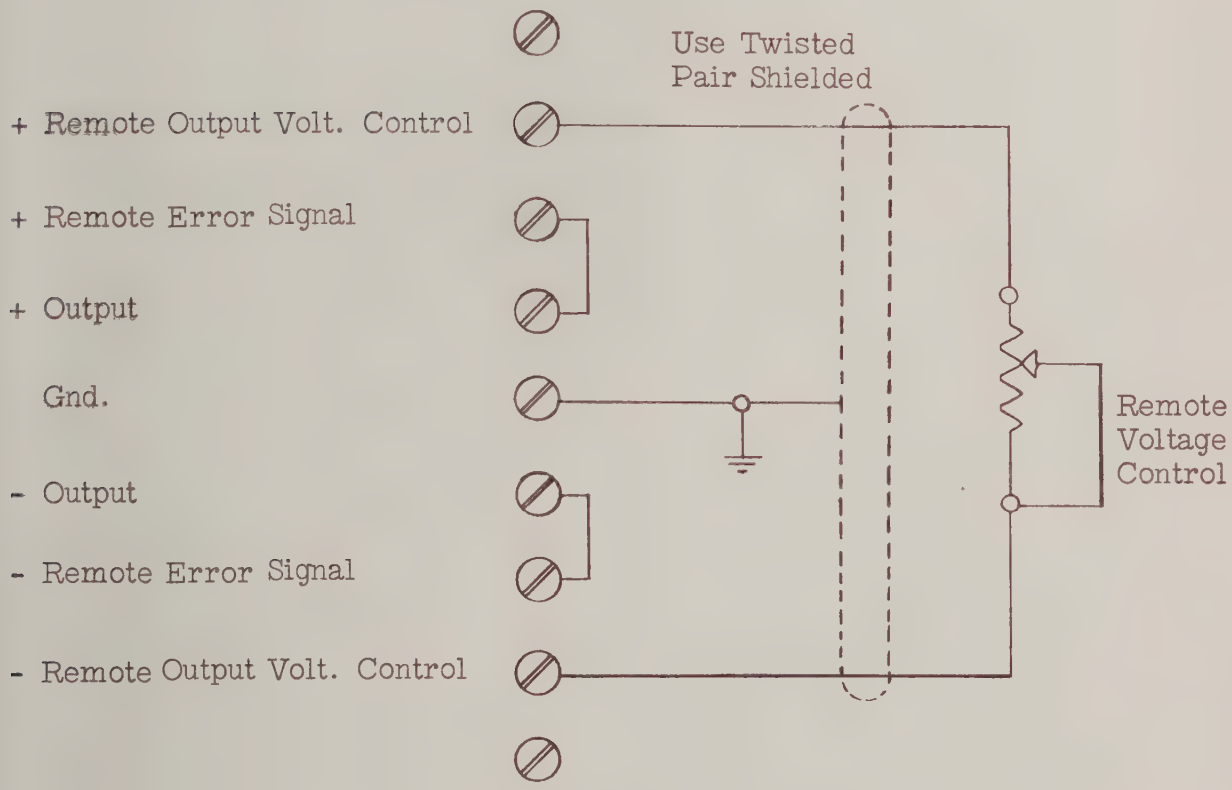


DIAGRAM II.

CONVERTING TO CURRENT REGULATED OPERATION

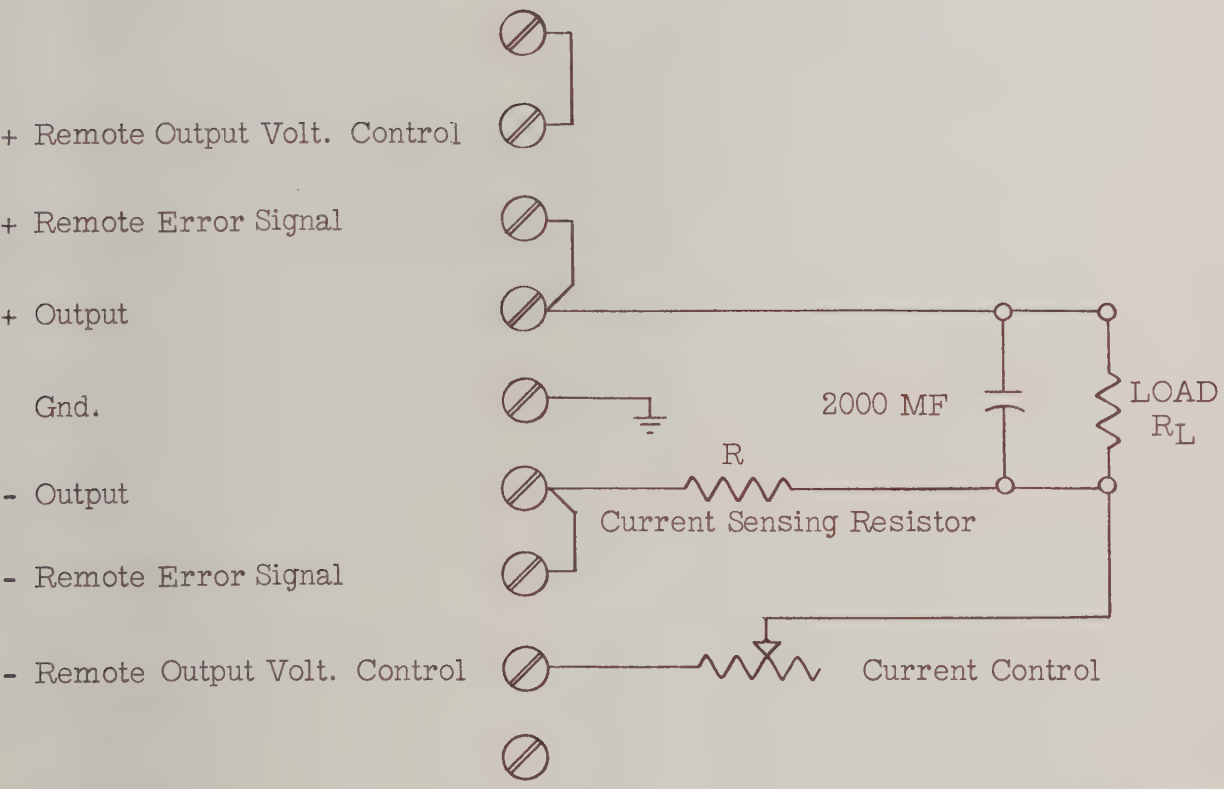


DIAGRAM III.

SECTION D

MAINTENANCE AND REPAIRS

.....GENERAL:

(1) In servicing this equipment it should be remembered that the essential regulating circuitry is a closed loop DC servo system. Careless servicing may affect the whole system. The same circuit sensitivity which enables a high degree of regulation to be obtained also increases the susceptibility of the circuit components to interrelated functional disorders when the equipment is abused. No component is an "island entire in itself". Consequently, exercise the greatest care in making repairs.

(2) Before any systematic trouble-shooting is attempted, it is advisable to establish by careful examination whether any malfunction is attributable to "simple" mechanical disorders: broken leads, loose plugs, etc. Obviously, many "simple" disorders may be symptomatic, that is, effects rather than causes of equipment malfunction.

(3) The components of this power supply have been tested and selected to provide long and trouble free operation. Under normal operating conditions, maintenance will consist merely in oiling the fan every six months. However, if component failure occurs the unit should be serviced by personnel who are thoroughly familiar with transistor circuitry. SERIOUS, COSTLY DAMAGE CAN RESULT FROM CARELESS PROBING.

(4) PARTS LOCATION: New, revised, Instruction Manuals include Parts Location Photos. These photos together with schematic diagrams should facilitate trouble-shooting and replacement.

(5) CONTROL UNITS: Control Units or "TRAMS" are of a semi-modular plug-in design. (However, it is necessary, according to the particular model, to remove bracket screws or stand-off screws before the CONTROL UNITS can be unplugged.)

....PRECAUTIONS:

(1) CHECK ALL TRANSISTORS BEFORE REPLACING ANY. IF ASSOCIATED TRANSISTORS ARE DEFECTIVE, THE REPLACEMENT MAY BE IMMEDIATELY RUINED.

(2) IF MAJOR REPAIRS ARE NECESSARY, THE FACTORY IS PREPARED TO HANDLE THEM. UNDER NO CIRCUMSTANCES SHOULD THE UNIT BE RETURNED TO THE FACTORY WITHOUT PROPER AUTHORIZATION AND SHIPPING INSTRUCTIONS. IN ANY CORRESPONDENCE WITH THE FACTORY CONCERNING REPAIRS, THE MODEL AND SERIAL NUMBER OF THE UNIT MUST BE GIVEN TOGETHER WITH A DESCRIPTION OF THE TROUBLE ENCOUNTERED.

(3) Check all fuses before applying power after any repairs or replacements have been made.

(4) If it is found that the output voltage cannot be varied over its entire range by means of the voltage control adjustment, be careful not to short the supply as severe damage to the unit may result. In this regard, if it is detected that the output voltage does not decrease as the

voltage control is turned counter-clockwise, DO NOT CONTINUE TO TURN THE CONTROL.

(5) If it is necessary to solder transistor terminals, it is recommended that the leads be held with pliers between the transistor and the point to be soldered in order to shunt heat and reduce the possibility of damage to semi-conductor junctions. This applies as well to semi-conductor diodes.

.....CHECKING TRANSISTORS:

(1) Since a transistor is essentially a combination of semi-conductor diodes, a short in both directions between any two of its terminals is sufficient indication that the transistor is defective. Characteristically, the ratio of the forward to the reverse resistance across a transistor junction should be at least 100. In the majority of cases, the bi-directional short will occur between the collector and emitter terminals. Occasionally, a short will occur between the base and either of the other two terminals, but this condition is usually compounded with an emitter-collector short.

(2) HIGH POWER TRANSISTORS - If possible, a power transistor checker should be employed, but on a Go-No-Go basis an ohmmeter will prove adequate to detect defective components. USING THE RX1 SCALE OF THE OHMMETER, TEST FOR SHORT WITH ONE POLARITY; REVERSING POLARITIES, TEST FOR SHORT IN THE REVERSE DIRECTION. PASS TRANSISTOR groups containing elements in parallel may be checked collectively without removal from the circuit. This is done by connecting an ohmmeter directly across the collector emitter terminals

of the pass elements. If any one of the transistors in parallel is shorted, the group will, of course, be shorted and require individual checking.

NOTE: PASS TRANSISTORS are mounted in most models on the chassis in plug-in heat sinks called "STATS". In early models these STATS could be disconnected simply by pulling the STAT plug from its socket. In the newer models, for increased structural rigidity, the STATS are fastened by self-tapping hex-head screws which must be removed from the underside of the chassis.

(3) LOW POWER TRANSISTORS - Can be adequately tested using standard "packaged" transistor checkers (e.g. Baird-Atomic Beta-h_{11} Model KT-1, Barber Labs. Junction Transistor Checker Model #29). IMPORTANT: BE SURE THE PNP-NPN SELECTOR SWITCH IS IN THE CORRECT POSITION.

NOTE: Associated with each PASS TRANSISTOR connected in parallel within a pass group is a low-value resistor, called an "equalizing resistor", which operates to equalize current distribution among the pass elements. It should be ascertained whether or not a defective equalizing resistor is contributing to or has resulted from operational disorders. If one of these resistors "burns open" it effectively removes a pass transistor from the main circuit and increases the dissipation requirements of the remaining elements.

.....REGULATION:

IT MUST BE STRONGLY EMPHASIZED THAT THE LOW ORDER OF MAGNITUDE OF THE REGULATION SPECIFICATION FOR THESE UNITS MAKES IT IMPERATIVE TO PROCEED WITH GREAT CARE IN MAKING REGULATION MEASUREMENTS. OTHERWISE, THE TEST APPARATUS WILL REFLECT INACCURACIES INTRODUCED BY THE TEST.

(1) Models provided with both front and rear output terminals require certain special considerations when precise regulation measurements are to be made. The front and rear output terminals are connected internally by a buss. This buss must be regarded as of sufficient magnitude to affect regulation when load current requirements are appreciable. Since the rear output terminals are closer to the error sensing terminals than the front output terminals, it is evident that a voltage difference will develop between front and rear when the load current is drawn through the internal buss. This is the case when the load is connected to the rear output terminals. In this case, it is not recommended that the regulation be measured or monitored at the front terminals. If the regulation is measured at the rear terminals it should be within specification.

(2) If the load is split between the front and rear output terminals, the load at the rear will receive the best regulation, while the front output voltage will be higher by the amount of voltage drop in the internal buss. Therefore, if optimum regulation is desired at the front output terminals, the rear output should not be loaded simultaneously because

the internal buss will carry a portion of the load current and introduce a proportional voltage drop between the output and the error sensing terminals.

(3) When front and rear outputs are provided, it is recommended that the load be connected to the front output terminals to measure regulation. The analyzer of scope connections should be made at the error sensing terminals.

(4) To avoid the considerable possibility of introducing voltage drops in clip lead connections when analyzing regulation of single output units, it is advised that the following connections be made: Using #14 wire, place a loop around each of the output terminals. Making sure that each loop is tightly secured at the binding posts, connect the leads from each loop to the load and the regulation analyzer or scope.

Cause numbers indicate order of probability

TROUBLE-SHOOTING CHART

SYMPTOM	CAUSE
A. NO OUTPUT	1. Overtemperature relay activated by: a. blocked ports b. ambient temperature too high c. defective fan d. defective relay 2. Input fuse blown by short in: rectifiers, transformer, transistors, main supply filter capacitor 3. Defective Control Unit (TRAM) 4. Defective ammeter
B. NO REGULATION HIGH OUTPUT VOLTAGE; VOLTAGE CONTROL DOES NOT DECREASE OUTPUT VOLTAGE (EXCEPT IN VARIAC UNITS).	1. Defective pass elements 2. Open Voltage Control Potentiometer 3. Defective Control Unit (TRAM) 4. Defective Driver or Pre-Driver associated with Pass Transistors
C. NO REGULATION LOW OUTPUT VOLTAGE	1. Current Limit Adjust set too low 2. Defective Control Unit (TRAM) 3. Incorrect conversion to remote error operation 4. Defective Main Filter capacitor

SECTION E

CONTROL ADJUSTMENTS

.....OUTPUT VOLTAGE CONTROL:

The output voltage of this supply may be varied continuously through its specified range by means of an adjustable OUTPUT VOLTAGE CONTROL.

.....CURRENT LIMIT ADJUST: (Designated CL on schematics)

The maximum safe current capacity of this supply is 120% of the rated supply. An automatic current limiting device in the Control Unit limits the pass current whenever the output current exceeds this value.

To accommodate special operation requirements, the screwdriver adjustment, called "CURRENT LIMIT ADJUST", is available on the Control Unit. The current limit can be thus manually set at any value in the range from 0 to 120% of the rated current supply.

NOTE: Current limiting adjustments available on this model are specified in Section A under "Protective Features".

FOR EXAMPLE: If it is desired to limit the output current to a maximum of 0.2 ampere, the procedure is as follows:

(1) Load the supply to at least 0.25 ampere.

NOTE: As the current limit is approached the supply regulation becomes slightly poorer. Consequently, for best regulation throughout the operating load current range, the current limit adjust should be set 25% higher than the maximum desired

output current.

(2) Turn the CURRENT LIMIT ADJUST control counter-clockwise until the output current reduces to 0.2 ampere.

In the above example the load regulation of the power supply will be within specification from 0 to 0.16 ampere.

.....MAXIMUM CURRENT ADJUST: (Designated MC on schematics)

Like the CURRENT LIMIT ADJUST, this limiter is part of the Comparison Amplifier circuitry in the Control Unit. The potentiometer associated with this control serves to establish a maximum safe current limit for the power supply. It is PRE-SET at the factory at a value equal to 120% of the maximum rated output current. When the output current tends to exceed this pre-set limit, the Pass Transistor biasing is automatically adjusted to reduce the pass current.

THE MAXIMUM CURRENT ADJUST SETTING SHOULD NOT BE CHANGED UNLESS IT IS REQUIRED FOR REMOTE ERROR SENSING OPERATION. (SEE IMMEDIATELY BELOW.)

.....MAXIMUM CURRENT ADJUSTMENT FOR OPERATION WITH REMOTE ERROR SENSING:

Unless the current limiters are adjusted for operation with remote error sensing the current supplied to the load will be limited to a value less than 120% of rated supply by the amount of voltage drop in the lead connections.

To avoid this limiting action, the following steps should be taken:

(1) Load the supply with a remotely connected resistor which will draw slightly more than 120% of the rated supply current at the indicated supply voltage.

(2) Turn the CURRENT LIMIT ADJUST to its maximum clockwise position.

(3) Turn the MAXIMUM CURRENT ADJUST clockwise until the output current is exactly 120% of the rated supply current.

(4) Turn the CURRENT LIMIT ADJUST counter-clockwise to limit the output current to any desired amount from 0 to 120% of maximum rated supply.

....RP CONTROL ADJUSTMENT:

Some control units contain a locking type screwdriver adjustment designated "RP ADJUST". In converting to REMOTE OUTPUT VOLTAGE CONTROL OPERATION it may be necessary to adjust the ohms/volt ratio to the value specified in SECTION A under REMOTE OUTPUT VOLTAGE CONTROL. With the unit set up for remote output control, loosen the locking nut and turn the RP potentiometer under the proper ohms/volt between the remote voltage control resistance and the output voltage is obtained. (e.g. in a 1,000 ohms/volt unit a remote voltage control resistance of 18,000 ohms obtains an 18 volt output.)

Be sure to tighten the locking nut after this adjustment has been made.

PARTS LIST

DRAWING S-TRAM-2-01

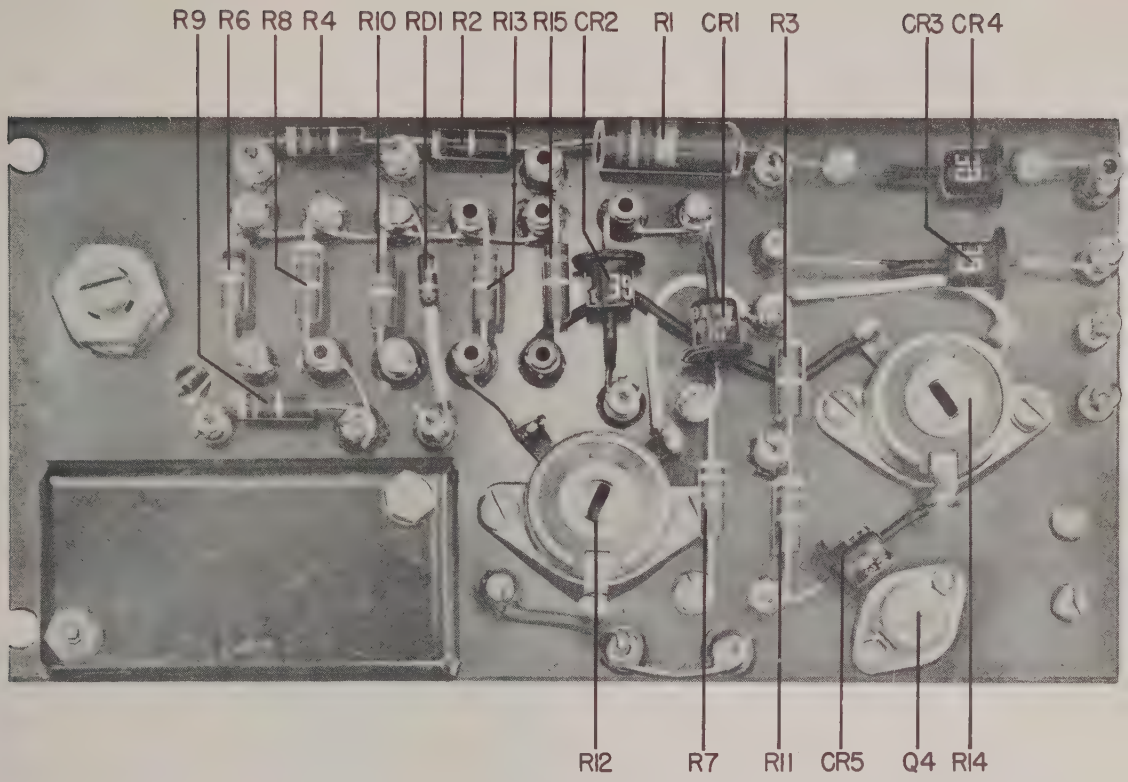
C1	- 500	MF	12 WV
C2	- 100	MF	12 WV
C3	- 100	MF	50 WV
C4	- 0.4	MF	50 WV
CR1 thru CR5	- Diode 1N91		
Q1	- Transistor GT-1092		
Q2	- Transistor 2N382 (Alternate 2N383)		
Q3	- Transistor 2N35 (Alternate GT-1092)		
Q4	- Transistor 2N382 (Alternate 2N383)		
R1	- 680	Ohm	1 watt
R2	- 620	Ohm	1/2 watt
R3	- 220	Ohm	1/2 watt
R4	- 4.7	K	1/2 watt
R5	- 5	K	2 watt Pot.
R6	- 10	K	1/2 watt
R7	- 430	Ohm	1/2 watt
R8	- 4.7	K	1/2 watt
R9	- 4.7	K	1/2 watt
R10	- 220	Ohm	1/2 watt
R11	- 4.7	K	1/2 watt
R12	- 500	Ohm	1.5 watt WW Pot.
R13	- 680	Ohm	1/2 watt
R14	- 2.5	K	1.5 watt WW Pot.
R15	- 2.7	K	1/2 watt
R16	- 47	Ohm	1/2 watt
~~R17~~	~~- 1.1~~	~~K~~	~~1 watt~~ Delete
RD1	- Reference Diode SV-13		
RD2	- Reference Diode SV-7		
T1	- Kepco #100-1026		

PARTS LIST - MODEL SC-18-0.5
MODEL SC-18-0.5M*

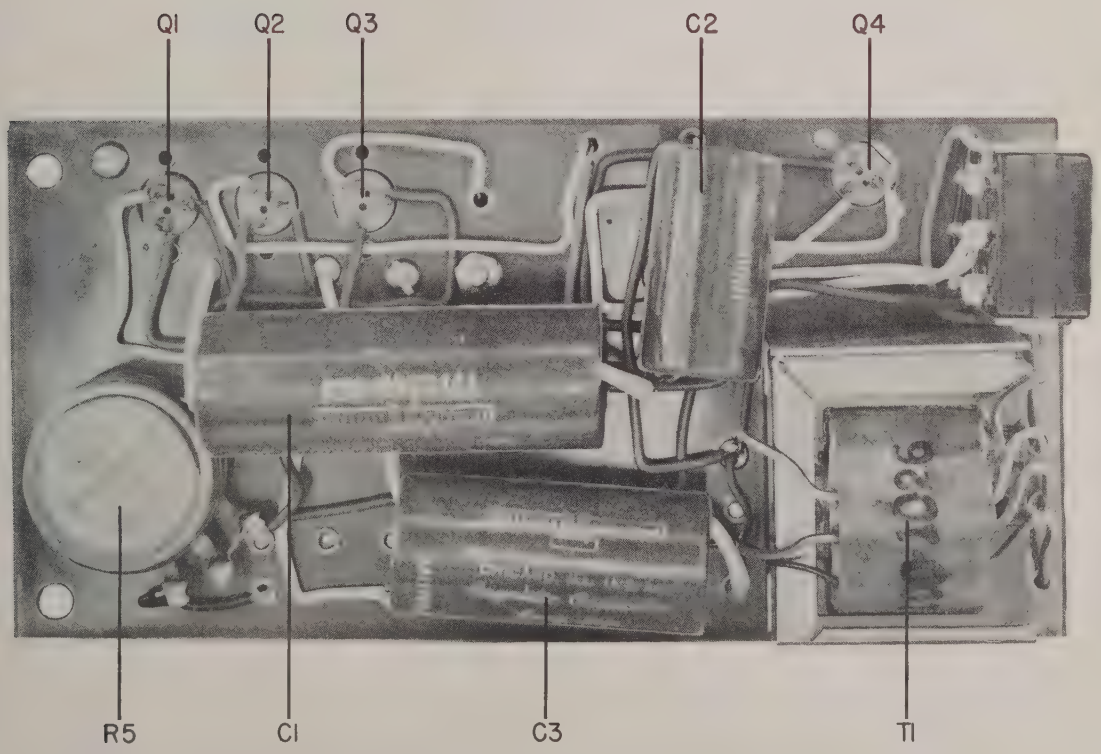
DRAWING S-SC-18-0.5-02

B101	- Fan		
C101	- 1000	MF	50 WV
C102	- 2500	MF	30 WV
C103	- 50	MF	150 WV
C104	- Omitted		
C105	- 0.02	MF	500 WV
C106	- 0.22	MF	200 WV
C107	- 0.1	MF	600 WV
C108	- 2	MF	200 WV
C201	- 10	MF	150 WV
C202	- 0.22	MF	200 WV
CR101 thru CR104	- Silicon Rectifier PT-5		
CR201 and CR202	- Silicon Rectifier PT-5		
F101	- 1 Amp. Fuse		
*M101	- Meter, 0-0.5 A DC		
*M102	- Meter, 0-20 V DC		
PL101	- Neon Pilot Light NE-51		
Q901	- Transistor 2N441-4		
R101	- 500	Ohm	20 watt WW
R102	- 1	K	2 watt
R103	- 20	K	2 watt Pot.
R104	- 5.6	Ohm	1 watt
R105	- 1	K	2 watt
R106	- 220	Ohm	1/2 watt
R201	- 330	K	1/2 watt
R202	- 1	K	5 watt
R901	- 1.5	Ohm	3 watt WW
RL201	- 3PDT Relay		
S101	- SPST Switch		
S102	- Thermoswitch N. C.		
T101	- Kepco #100-1020A		
TB101	- Jones #9-140-Y		

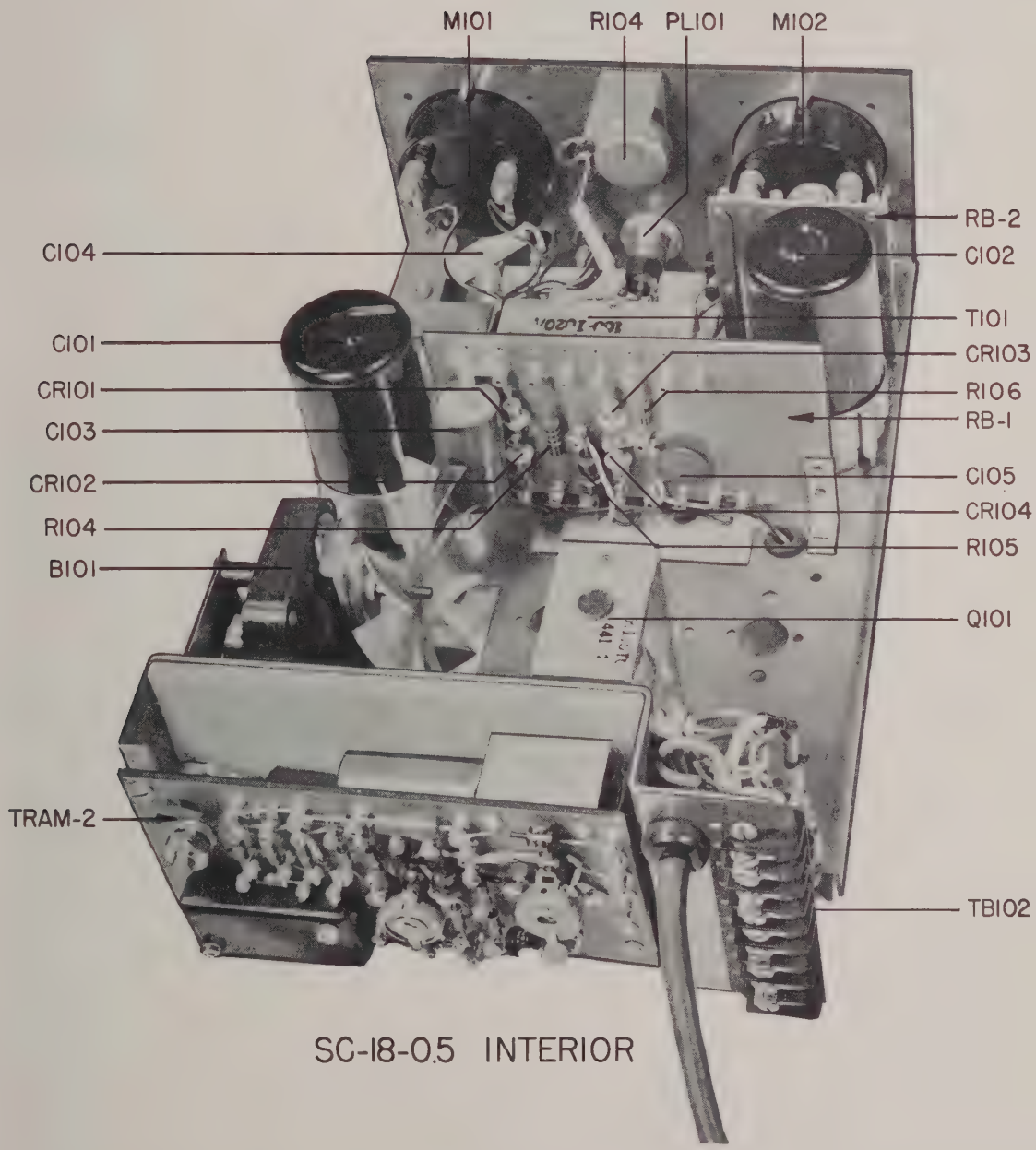
TOP



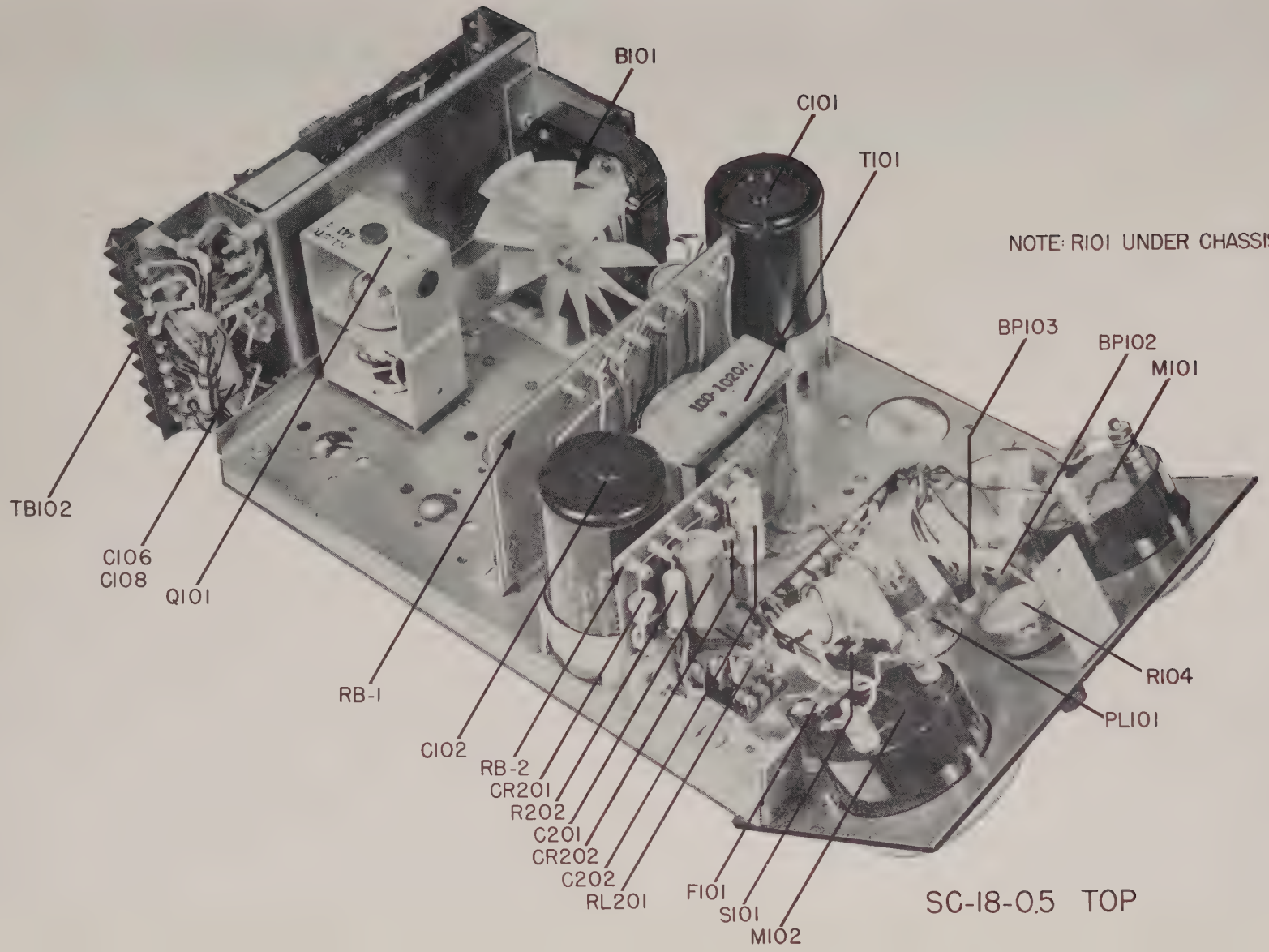
BOTTOM



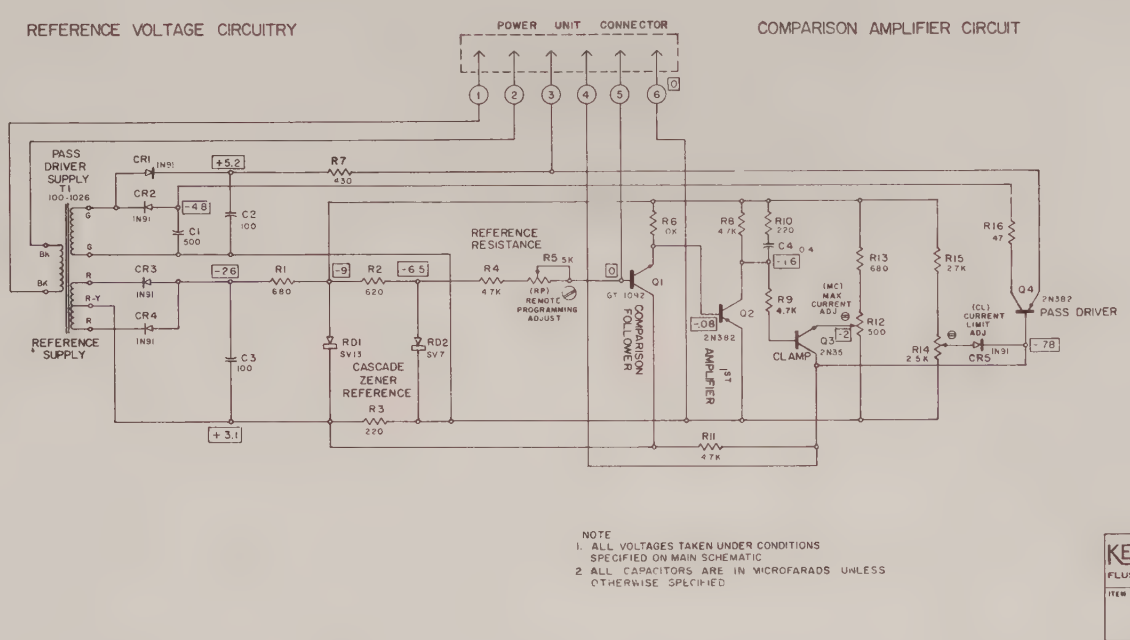
TRAM 2



SC-18-0.5 INTERIOR


B101
C101
T101
NOTE: R101 UNDER CHASSIS
BP103
BP102
M101
TB102
C106
C108
Q101
RB-1
R104
PL101
C102
RB-2
CR201
R202
C201
CR202
C202
RL201
F101
S101
M102

SC-18-0.5 TOP



NOTE
1. ALL VOLTAGES TAKEN UNDER CONDITIONS SPECIFIED ON MAIN SCHEMATIC
2. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED

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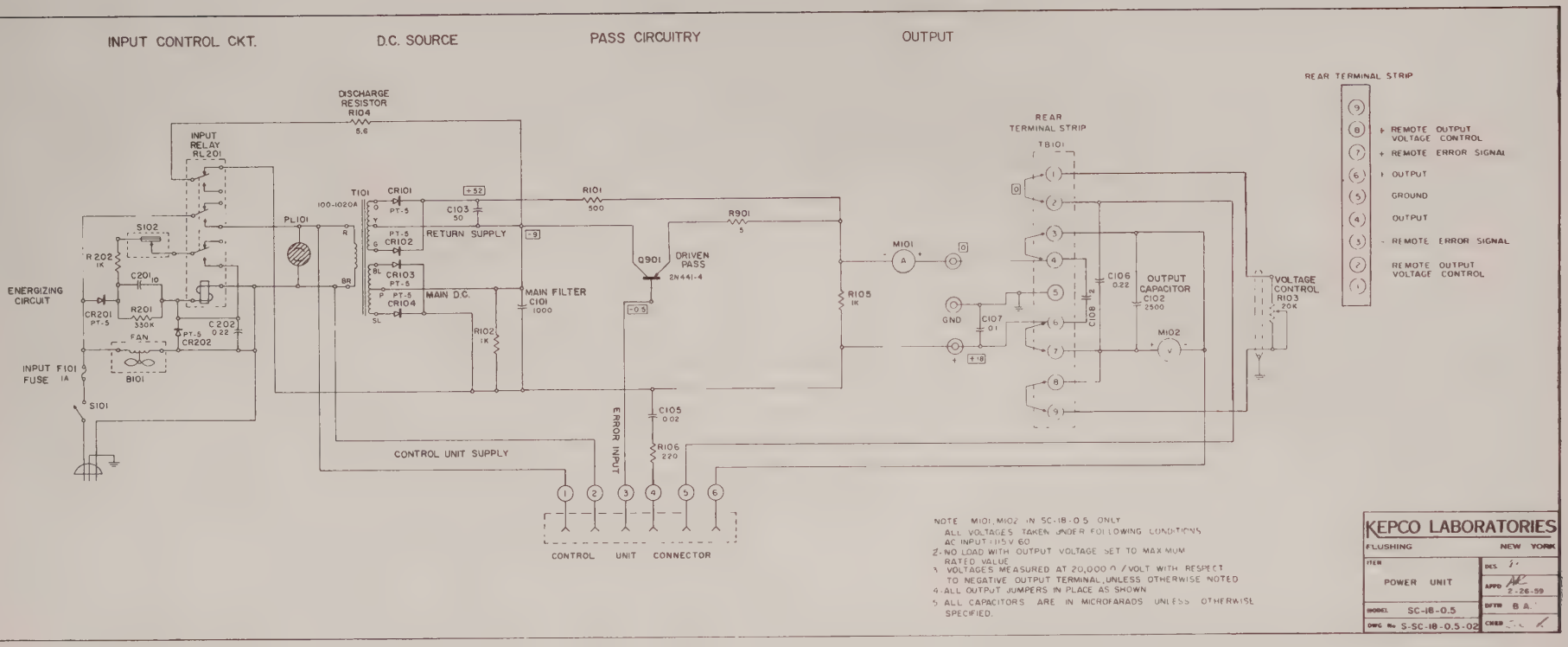
ITEM: CONTROL UNIT	DES. A.A.R
	APPD K.K 3-17-59
MODEL TRAM-2	DFTD W.S.
DWG. No S-TRAM-2-01	CHKD B



NOTE M101, M102 IN SC-18-0.5 ONLY

1. ALL VOLTAGES TAKEN UNDER FOLLOWING CONDITIONS AC INPUT = 115 V 60
2. NO LOAD WITH OUTPUT VOLTAGE SET TO MAXIMUM RATED VALUE
3. VOLTAGES MEASURED AT 20,000 Ω / VOLT WITH RESPECT TO NEGATIVE OUTPUT TERMINAL, UNLESS OTHERWISE NOTED
4. ALL OUTPUT JUMPERS IN PLACE AS SHOWN
5. ALL CAPACITORS ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

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ITEM POWER UNIT	DES.
	APPD 2-26-59
MODEL SC-18-0.5	DFTD B.A.
DWG No S-SC-18-0.5-02	CHKD

first in
Performance
Reliability
and Quality
Kepco